GROOMING THROUGH THE REPRODUCTIVE CYCLE IN MALE *SINELLA COECA* (COLLEMBOLA: ENTOMOBRYIDAE)*

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Introduction

Pheromones function in several roles important in insect reproduction: location of associate, species recognition, sex recognition, and as aphrodisiacs. The receptors that detect most sex pheromones are located on the antennae and mouth parts. Grooming behaviors free these sensory surfaces of foreign materials permiting their optimal functioning.

Collembola are commonly very abundant in leaf litter and soil ranging up to 200,000 per m^2 (Hale, 1967). They contribute by their food processing and locomotion to soil genesis and the maintenance of soil fertility. Their abundance is due not to a large diversity of species, but to a high reproductive potential (Kuhnelt, 1961).

Reproduction utilizes indirect sperm transfer via stalked spermatophores. In *Sinella curviseta* Brook (Family Entomobryidae) spermatophore deposition by males is stimulated by a female sex pheromone (Waldorf, 1974a). Under ideal conditions, *Sinella curviseta* females can deposit an average of 45 eggs every 8 days for 3 months (Waldorf, 1971; Niijima, 1973). Both sexes in this species release gametes during specific intervals that alternate with nonreproductive periods (Waldorf, 1971). Males and females molt twice between successive reproductive intervals.

Although reproduction has not been described in *Sinella coeca* (Schott), preliminary work suggested that the frequency of cleaning might vary with the reproductive condition of the individual (Waldorf, 1974b). These data demonstrate a difference between the sexes in the frequency of grooming, with males grooming more often. In addition, the frequency of grooming in females depends on the reproductive condition of the female.

This study examined the frequency of grooming in *Sinella coeca* males in a sequence of reproductive conditions. Since females with

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eggs groom more often than other females (Waldorf, 1974b), I expected males depositing spermatophores to exhibit a higher rate of grooming.

Methods

Mass cultures of *Sinella coeca* were maintained as previously described (Waldorf, 1971). Animals were held at room temperature (25-26°C) in constant light. Brewer's yeast was provided as food and replaced as the supply became contaminated with fungal growth.

Ten pharate males were isolated in individual plastic-capped glass vials. The vials with an inner diameter of 22.0 mm contained a moist plaster of paris-charcoal substrate and food. Each male was observed for five minutes every 12 hours for 10 days. With the observor wearing a fiber mask to reduce disturbance of the animals, observations were begun 12 hours after isolation. Records were made of number of bouts of antennal grooming, total number of bouts of grooming and total seconds grooming. For the latter an electric second counter was activated by a depression switch. In addition, exuvia were removed and their presence recorded, and observations of spermatophore deposition behavior were noted.

Table 1. The lengths of reproductive and nonreproductive instars in male *Sinella coeca* in days at 25-26°C.

	Reproductive instar	Nonreproductive instar
Instar length	5.4	3.1
SD	1.006	.512
No. of males	10	9

Results

Spermatophore deposition behaviors occur in *Sinella coeca* only in alternate instars. The lengths of the two types of instar (Table 1) differ significantly ($t = 6.62$, df 17; $P < .005$). The reproductive instars average 5.4 days, one and ¾ times the length of the nonreproductive ones.

The percentages of the males exhibiting spermatophore deposition behavior through the reproductive instar appear in figure 1. The maximum occurred early in the instar with all males depositing spermatophores spontaneously 24-36 hours after ecdysis. There is a

gradual decline until 6 hours prior to the next ecdysis when no males exhibited this behavior.

Neither the number of bouts of cleaning nor the lengths of these differed in reproductive as compared with nonreproductive males. The averages, considering all grooming, are presented in Table 2. Similarly, there are no differences in antennal grooming as a function of reproductive condition.

The average frequencies of grooming through the instars are illustrated in figure 2. The patterns in reproductive and nonreproductive males are essentially the same. Both groom most frequently 12-18 hours after ecdysis. Thereafter a lower rate is more or less constant until 70-75% of the instar has elapsed. This declines to near zero before ecdysis. Of the 11 pharate males observed in previous experiments, only one performed one antennal cleaning.

Table 2. The average number of bouts of grooming in 5 min. and their average duration in male *Sinella coeca* in the reproductive and nonreproductive instars.

	No. of bouts per animal			Length of bouts (in sec)		
	$\bar{x}$	n	SD	$\bar{x}$	n	SD
Reproductive instar	1.3	10	.518	25.93	98	15.86
Nonreproductive instar	1.3	10	.441	23.43	49	10.48

Discussion

The pattern of alternate reproductive and nonreproductive instars observed in *Sinella coeca* characterizes both sexes of *Sinella curviseta* (Waldorf, 1971) and some members of the genera *Orchesella, Tomocerus* and *Isotoma* (Poggendorf, 1956; Mayer, 1957; Joosse and Veltkamp, 1970). Similarly, reproductive instars are longer in males of *S. curviseta* (Waldorf, 1971) and *Orchesella cincta* L. (Poggendorf, 1956) than nonreproductive ones. Although not enough data are available to draw a conclusion, this pattern might apply generally within the family Entomobryidae.

The experimental observations of isolated males provided estimates of the frequency of spontaneous grooming. The data indicate that the rate of spontaneous grooming does not vary between types of instar but does vary within instars.

Fluctuations in response to female (or male) associates might be superimposed on the basic pattern (fig. 2). An example of the effect

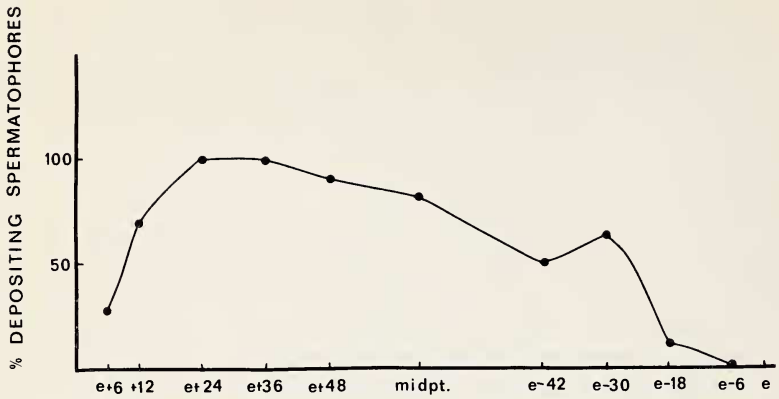

Figure 1. The percentages of males depositing spermatophores through the reproductive instars. Ages are given in hours relative to ecdyses (e) at the onset and conclusion of the instar.

of association has been reported in *Sminthurides aquaticus* Bourlet (Mayer, 1957). Males of this springtail clasp the antennae of females and are carried about by the females. Such males groom more than unattached males.

The previous finding (Waldorf, 1974b) that *Sinella coeca* males groom more frequently than females is possibly explained by the positive correlation reported by Jander (1966). She found higher rates of grooming in animals that exhibited more locomotor activity. *S. coeca* males are more active than females.

This correlation receives further support from comparison with *Sinella curviseta* males. *S. coeca* males groomed their antennae about 1.8 times in 5 min. This contrasts with .4 antennal cleanings observed on the average in five min (at the same temperature) in the less active *S. curviseta* males ($n = 10$; $SD = .70$).

My earlier data (1974b) on variation in grooming in *S. coeca* females, although less precise, was similar to the pattern in males shown in figure 2. In that experiment the category termed newly ecdysed females (ecdysis (e) to e + 22 hours) exhibited moderate frequency of grooming; females with eggs (e + 24 to e + 44 hours) exhibited the highest frequency of cleaning; and, other females (>e + 24 hours in nonreproductive instars and >e + 44 hours in reproductive ones, assuming these occur) exhibited the lowest. Since these females were observed at 23°C (in contrast to 25-26°C for males in the present experiment), the hours cannot be compared exactly.

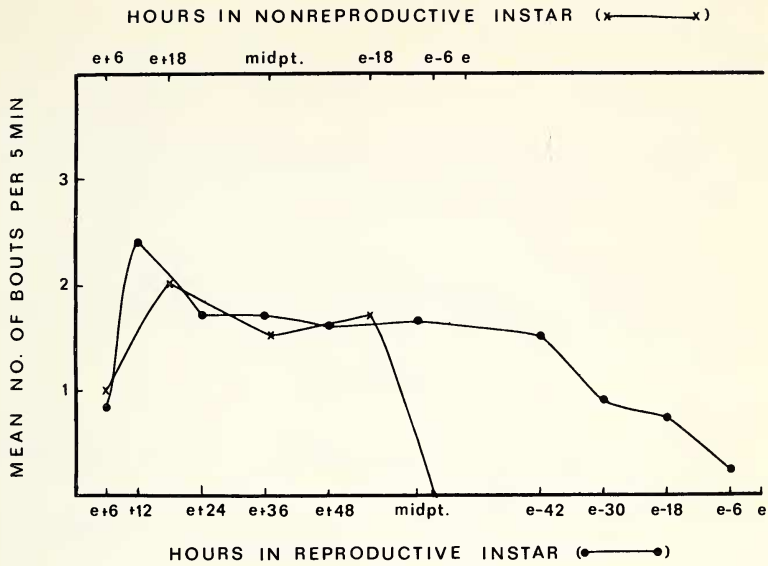

Figure 2. Average number of bouts of grooming behavior in 5 min through the reproductive and nonreproductive instars. Ages are given in hours relative to ecdyses (e) at the onset and conclusion of the instars.

Lepidocyrtus cyaneus Tullberg cleans its antennae twice in five minutes and its legs an average of 1.3 times (Pedigo, 1967). These compare with 1.8 times for antennae and a smaller value for leg grooming in male *Sinella coeca.* These rates are remarkably similar, perhaps indicating equal rates of locomotor activity in the two species. However, if *Lepidocyrtus* males are more active than females, those frequencies might be averages of the higher rate of grooming in males with the lower one in females.

The location in instars of the maximum grooming rate is of interest. In *S. curviseta,* females pick-up and utilize sperm only during about the first 20 hours of the reproductive instars (Waldorf, 1971). During this interval females release a volatile sex pheromone that increases male spermatophore deposition (Waldorf, 1974a). Further Joosse (1975) reports that certain events synchronize molting in natural populations of species of Entomobryidae. Consequently, if *Sinella coeca* females are similar to *S. curviseta* ones, the maximum spontaneous grooming in males might often coincide with the presence of the female sex pheromone.

In *Orchesella cincta* males, spermatophore deposition occurs typically only in the first half of the reproductive instar (Joosse, Brugman and Veld, 1973). The maximum number of males of *Sinella coeca* exhibit spontaneous spermatophore deposition in the first half of the instar. If reproduction in *S. coeca* females resembles that in *S. curviseta* and synchronization of molting occurs, *S. coeca* females probably have access to an abundance of spermatophores.

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